TITLE OF THE INVENTION

GAMUT FALSE COLOR DISPLAY

BACKGROUND OF THE INVENTION

The present invention relates to video picture analysis, and more particularly to a display format for viewing gamut errors in video pictures being analyzed.

Color video pictures may be represented in several different formats at different times during video processing. The color video pictures may be in an analog composite format, such as NTSC or PAL, in an analog component format, such as Y,P_b,P_r, in a digital component format, such as SMPTE 125M, in a primary color format, such as RGB, etc. In the course of processing the color video pictures there may be several conversions between the different formats. Each format has a different color space so that it is possible to produce colors in one format that are not reproducible in another format. The inability to reproduce a particular color from one color format in another color format is known as color gamut error.

Additionally analog composite signals usually have certain limits imposed on them for the proper operation of the broadcasting or receiving circuits. Composite signals that exceed a specified signal limit are referred to as having signal limit errors. For simplification color gamut and signal limit errors are referred to as gamut errors herein.

One method of detecting gamut error is disclosed in U.S. Patent No. 4,707,727 where a color television signal in one format, such as component analog, is converted into a display format, such as primary color. The

amplitudes of each component are compared with respective high and low thresholds such that, if either threshold is crossed, an error indication is generated. Such indication may be displayed simply as a light on a panel, or as a blanking, cross-hatching or false coloring on a display. The error indication may also be used to initiate a color correction of the pixels generating the error indication to bring the color of the pixels within gamut, i.e., within the reproducible colors of the new color space. The QA100 quality analyzer manufactured by Pinnacle Systems, Inc. of Mountain View, California, originally designed and manufactured by Hewlett-Packard of Palo Alto, California, is an example of the use of false coloring of any out-of-gamut pixels, while the WFM700 waveform monitor manufactured by Tektronix, Inc. of Beaverton, Oregon is an example of overlaying a cross-hatch pattern across out-of-gamut pixels. Both of these methods overlay across normal full color video, and hence make it difficult to see if the gamut error occurs where there is a lot of color, motion, edges, etc., or if the gamut errors themselves occur in small patches.

What is desired is a display of gamut errors that doesn't hide the underlying video picture so it is easier to analyze the cause of the gamut errors.

BRIEF SUMMARY OF THE INVENTION

Accordingly the present invention provides a gamut false color display that uses false coloring on a monochrome image of a video picture being tested. Composite and component gamut error signals are extracted from an

input video signal representing the video picture being tested, where monochrome is defined as equal values of Red, Green and Blue, or "no-color." Such error signals may represent gamut error states corresponding to near out-of-gamut, out-of-gamut high, out-of-gamut low, etc. A false color display generator has the gamut error signals and a luminance component of the input video signal as inputs and outputs the gamut false color display as the monochrome image with different colors for those pixels in the monochrome image that correspond to the gamut error signals when a gamut error is indicated. Each display component may be tested for gamut errors as well as the video picture as a whole (component or composite). Also either fixed or variable persistence may be used to identify gamut errors over several video pictures in the input video signal. A counter may be used to count the gamut errors detected in order to take a "snapshot" of the gamut error display when a predetermined error limit is reached.

The objects, advantages and other novel features of the present invention are apparent from the following detailed description when read in conjunction with the appended claims and attached drawing.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

Fig. 1 is a block diagram view of a gamut false color display logic according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Fig. 1 an example of the video processing for a video picture signal in one format, such as component video Y, C_b, C_r, which is converted into a display format, such as primary RGB, and includes gamut error testing is shown. The input video signal is input to a chrominance magnitude generator **12** and a color converter **14**. Chrominance components of the input video signal are converted to a chrominance magnitude signal $\mathbf{C_{Mag}}$ by the chrominance magnitude generator **12**, which chrominance magnitude signal is input to an adder **16** and a subtractor **18**. Also input to the adder **16** and subtractor **18** is a luminance component of the input video signal. The output from the adder **16** is input to first and second comparators **20, 22** together with respective high and near high threshold values. The output from the subtractor **18** is input to third and fourth comparators **24, 26** together with respective near low and low threshold values. The outputs from the chrominance comparators **20-26** are boolean values.

The components of the input video signal input to the color converter **14** provide, in this example, three primary color outputs -- Red, Green and Blue. Each primary color is input to respective sets of four comparators **28-44** together with respective high, near high, near low and low threshold values. The boolean outputs from the primary color comparators **28-44** as well as the outputs from the chrominance comparators **20-26** are input to a false color display generator **48** that includes a frame buffer.

The video picture being analyzed for gamut errors, as represented by the luminance component **Y**, is displayed by the false color display generator

48 on a suitable monitor, such as a VGA monitor, in monochrome. The luminance component is used to set the intensity of the display pixel monochrome data. Any portion of the video picture that is close to being out of gamut, as indicated by the boolean values from the chrominance comparators **20-26** and primary color comparators **28-44**, is modified with a first color, such as yellow. Any portion of the video picture that is out of gamut low is modified with a second color, such as blue. Finally any portion of the video picture that is out of gamut high is modified with a third color, such as red. In other words if no gamut boolean value is "true", then only monochrome (no-color) is displayed, otherwise the appropriate color is displayed according to which gamut boolean value is "true". The number of different colors used, the particular colors used and the thresholds for their occurrence may be completely programmable. Thus from the high, near high, near low and low boolean values the false color display generator **48** provides the appropriate false color outputs for the display.

The advantage of this gamut false color display format for gamut error detection is that every portion of the video picture may be easily identified as being in gamut, close to being out of gamut, or out of gamut while the content of the video picture is readily discernible. Further knowing the position and effective area of the gamut excursion allows a viewer to gauge the severity of the gamut error. Errors outside of the picture "safe area" (the principal viewing focus area of a video picture -- usually the center area), for instance, are less severe than errors inside the safe area. Small or pinpoint gamut errors, even over the entire display screen, are much less severe than concentrated gamut excursions in one area of the screen.

To enhance the usefulness of this display format a variable or fixed persistence may be added to the gamut excursion color, using the frame buffer in the false color display generator **48**. The false colors may also have a programmable priority such that lower priority colors do not overwrite higher priority ones. Variable persistence facilitates the detectability of short duration gamut excursions, while fixed persistence allows a gamut test to be applied to an entire video sequence without requiring a person performing the gamut test to be present. Additionally automated capability may be put in place using a field gamut error counter **50** and a timestamp/snapshot logic **52** that takes a snapshot of the gamut display when a large number of gamut excursions has been detected to occur within a field of video. If a snapshot is performed, the persistence is reset.

While displaying the video picture in monochrome, different components of the video picture may be individually tested for gamut errors. For instance only the Red component of the video picture may be checked for RGB gamut errors to produce a false color upon gamut excursion.

Thus the present invention provides a gamut false color display by converting an input video picture signal to a display color format and by separating a chrominance magnitude from luminance in the input video picture signal. The chrominance magnitude is combined with the luminance component and compared with different thresholds to determine composite gamut error, and the display color components are compared also with different thresholds to determine display component gamut error. The boolean values from the comparisons are processed to provide a false color

for the display at pixels where the pixels of the input video signal are near to or actually out of gamut, a different false color being used for each gamut error state, otherwise the pixels are displayed in monochrome.